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USSR Report

MATERIALS SCIENCE AND METALLURGY

(FOUO 1/80)

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USSR REPORT

MATERIALS SCIENCE AND METALLURGY

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FERROUS METALLURGY

STEEL INDUSTRY ELECTRIC POWER FACILITIES DISCUSSED

Moscow STAL' in Russian No 10, Oct 79 pp 730-734

[Article by Candidate of Technical Sciences B. I. Kudrin, Gipromez: "Electric Power Engineering in Ferrous Metallurgy"]

[Text] Ferrous metallurgy has been and remains a major consumer of electric power. In connection with increase in output volume and retooling of this branch of industry, consumption of electric power is steadily increasing. Increased efficiency of utilization of electric power in ferrous metallurgy is of great economic importance, since considerable funds (12-15% of total capital investments in the branch) are expended on plant electrical facilities. At the modern metallurgical enterprise electricians comprise approximately 10% of the total work force.

The plan of future development and distribution of ferrous metallurgy calls for further improvement and extensive adoption of advanced methods of metal production and improvement of metal quality, with priority growth of electric power engineering. This increases the importance of decisions made when designing electric power facilities and enhances the role of study of trends in development of electric power engineering.

Further development of ferrous metallurgy will be accompanied by an increase in consumption of electric power and quantity of installed equipment. A number of factors will possess great significance:

1) expansion of production and movement on-stream of very large major power-consuming units and shops;

2) intensification of production and improved production efficiency by changing the areas of application of energy -- employment of electric power in place of thermal energy and fossil fuels;

3) direct utilization of electric power in the industrial process (for example, in electric steelmaking);

4) improvement in product quality, particularly on the basis of expansion of so-called fourth conversion;

5) performance of measures to achieve further improvement in working conditions and sophistication of production.

The trend toward an increase in consumption of electric power is unquestionably progressive. Studies conducted in various sectors of the economy have shown that growth in the power-worker ratio is in a close correlation with growth in labor productivity. Therefore power engineers in ferrous metallurgy, while taking all measures to achieve savings in electric power consumption, should work continuously to ensure a further rise in the level of electrification of this branch of industry.

As we know, required for electrification of a metallurgical enterprise are mutually coordinated solutions in three large areas: electric power supply; electric drive motors, power equipment, and automation; organization and management of electric power facilities (this area includes organization of repair and maintenance service).

The electric power facilities of the modern enterprise constitute a unified subsystem characterized by an aggregate of indices. Electric power facilities should provide users with electric power of a specified quality or convert it to other kinds of energy with a specified degree of continuity without interruption (process of provision and conversion) and viability (the subsystem as a whole and its separate parts), with restrictions on consumption of resources.

Electric Power Supply

Electric power supply is a most important part of electric power facilities. Relatively low cost (2-5% of the total estimated cost of plant construction) and considerable detriment from interruption in power supply or diminished quality of electric power constitute a specific feature of electric power supply at modern enterprises; this warrants additional expenditures on improving the reliability of electric power supply, expenditures which are continuously increasing as the branch grows and develops.

In the most recent period (beginning with the 1960's) research and proposals on designing electric power supply systems for ferrous metallurgical enterprises were based on the following points, which for the most part remain mandatory in designing at the present time as well:

1. 110-220 kV deep-leadin systems should be employed, with step-down substations broken down into smaller units and with step-down transformers brought as close as possible to the power-using facilities.

2. The level of insulation of in-plant power transmission lines and substation outdoor distribution system equipment should be in conformity with the state of the industrial atmosphere. It is not recommended that bus bars and distribution systems with light insulation be employed in metallurgical shops.

3. Power to power-consuming equipment with a sharply-variable impact load as well as with surges of reactive power should employ separate step-down transformers with emergency backup from transformers designated for "tranquil" power users or from common transformers under the condition that the high-voltage side of shop illumination transformers is fed from other sources with a normal voltage level.

4. Separate power lines running from plant generator facilities should be provided for part of the load of critical power users, interruption in the power supply of which cannot be permitted. If an enterprise lacks such power sources or if it is necessary for particularly critical units or equipment to continue operation, it is essential to design a backup power installation, backup pumps, connecting piping between various pumping stations, etc.

5. A single sectioned (into three sections) system of buses with independent leadins with a carrying capacity of 50-75% of the substation's load should be provided at shop power substations of blast-furnace and steelmaking shops and pumping stations. The quantity of process units and equipment should be coordinated with the adopted system of sectionalization of buses.

6. Indoor distribution systems of 6-10 kV deep leadin substations should as a rule be sited at locations (if possible colocated with equipment rooms) immediately adjacent to power users. When designing rolling-mill departments it is important to provide the capability of placing the outdoor portion of substations in the immediate vicinity of machinery rooms.

7. The electrical equipment portion of designs should provide for the capability of mutual backup of AC and DC shop systems. Powering of two or more power transformers from one high-voltage unit should not be permitted.

The level of distribution voltage has risen in conformity with increase in the electric power requirements of metallurgical enterprises. At the present time 500 (750) kV lines are being built or have been built in the area of the majority of large metallurgical plants, since 220 (330) kV proves insufficient. Lines at 110 kV are utilized as in-plant distribution lines; 35 kV is retained only for powering certain users, such as electric steelmaking furnaces; 10 kV has become the principal operating voltage for high-powered motors (in place of 6 kV); a voltage of 0.4 kV (380/220 V system) has been retained for small motors, although plans call for a change to 660 V in the future.

Various complete systems have come into widespread use in recent years:

1) combined distribution systems (KRU) in 10(6) kV circuits with boxes for rated currents of 630-3200 a (in some cases up to 5000 a) and switchoff currents of 20 and 31.5 ka (in some cases 58 ka). Low-oil-content circuit breakers are installed in these systems (primarily types VMP

and VMG with switchoff power of 350 MV·a at 10 kV), and when frequent switchings are necessary -- circuit breakers with electromagnetic arc suppression;

2) 10(6)/0.4 kV combined transformer substations (KTP) with 250-2500 kV·a transformers (dry and oil). The 0.4 kV distribution system is equipped with automatic circuit breakers (AVM, Elektron) and switch-circuit breaker units;

3) combined capacitor installations (KKU) for reactive power compensation in circuits with undistorted sine-waveform voltage curve and without a sharply-variable reactive load diagram;

4) combined semiconductor rectifier substations and installations (KPP, KPPP, KPU) for feeding 230 and 460 volt power-line loads and special equipment;

5) 10 kV combined symmetrical shielded current carriers with rated points to 3200 a.

Electric power supply to industrial plants at the power system level is presently provided from at least three power sources (heat and electric power plant or area power system substation URP [expansion unknown]). For most large plants a second heat and power plant is built -- a thermal electric power plant (TES), the designation of which has fundamentally changed. The TES does not perform the functions of a TETs-PVS [expansion unknown]; it is located outside the plant (or directly adjoining), at a distance exceeding that possible for power transmission at generator voltage; the adopted unit power of the generators (150, 200, 300 MW) dictates their voltage, which does not conform to that required for high-powered electric motors (10 kV) and predetermines power output to a URP by a block diagram or construction of 110 kV distribution systems at the TES.

Beginning in the 1960's, there has been a rapid growth in the number of main step-down substations (GPP) and deep leadin substations (PGV), the differences between which are becoming insignificant. A GPP is built for practically every shop, and as many as four GPP for a rolling-mill department. The majority of GPP are two-transformer and are set up in a simplified arrangement -- with a dead connection to a transformer without switching equipment, with maintenance disconnecting switches or isolating switches on leadins, with isolating switches and short-circuiting devices.

When possible, 10(6) kV distribution systems can be combined with distribution systems of shop substations. A single system of collecting bars, sectioned according to the number of transformer windings (paired reactance coil branches), is employed on the 10(6) kV side of the main step-down substations. In view of the fairly frequent emergency shutoffs on the 110 and 220 kV side (two to five per year), designers are returning to installation of switches on the high-voltage side, since GPP transformers cannot be connected to 110-220 kV mains by means of seal-offs with the aid of isolators and short-circuiting devices for powering important users.

Electric Motors, Power Equipment and Automation

Since the mid-1960's the process of adoption of static devices and elements has been logically combined with total automation and creation of automated industrial process control systems based on computers.

At the present time we must devote special attention to matters of economics when making technical decisions pertaining to electric motive power, power equipment and automation, bearing in mind the high cost of electrical equipment, the size of electrical equipment facilities, the volume of electrical installation work required, and electrical equipment operating costs. Analysis of the designs of a number of metallurgical plants has shown that the average cost of 1 ton of equipment in comparable prices has increased by approximately 70% in a period of 7-10 years. Expenditures on electrical equipment, instrumentation and automatic control devices have increased by 170%. The cost of electrical equipment and automation equipment for new rolling mills already exceeds the cost of the process equipment itself; the floor space required for placement of electrical equipment comprises 20-25% of total shop floor space, while in certain instances the expanded area of equipment rooms exceeds shop floor area.

Controlled DC electric power equipment in the thin steel sheet shop under construction at the Karaganda Metallurgical Combine is laid out according to the scheme T-M (thyristor inverter-motor). More than 400 complete thyristor devices of Soviet manufacture and 285 Czechoslovak-made thyristor-inverter boxes are provided here for electric drive power for rolling mills and other equipment. Standardized logic control systems based on various radio components are utilized for centralized lubrication systems and pumping-battery station drive mechanisms. Eight control computers and 32 local automation systems, 48 10/0.4 kV transformer substations with a total output of 92.5 MV·a, six 10 and 6 kV distribution substations, and 6100 electric motors with a total output of 300 MW are being installed. Such a system requires a large staff of highly-skilled operating and maintenance personnel and special setup, adjustment and laboratory equipment.

Considerable difficulties arise in operating such equipment. The electrical equipment system should be continuously evolving, but taking into account analysis of diversity of installed equipment. It is essential that new electrical equipment, such a thyristor converters and other devices manufactured by different plants for identical operating and load conditions, be standardized in design and circuitry.

Employment of DC and AC combined thyristor inverters remains the principal trend in designing controllable metallurgical electric drive mechanisms. The simplest and cheapest transformerless thyristor inverter design is widely employed for electric drive mechanisms powered from a 380 volt line. In order to reduce the size and improve operational indices of Soviet-built combined thyristor inverters it is necessary to continue work on adoption of more advanced types of thyristors and component items: 500-1000 amp tablet thyristors with recurrent voltage up to 3000 volts, symmetrical and fully controllable rectifiers up to 300-500 amps, 500-1000 volts, small, high-speed circuit breakers and automatic cutoff switches, unsaturable (air) reactance coils, low-noise individual cooling fans, high-reliability plug connectors and terminal blocks. It is necessary to design a uniform metallurgical series of thyristor inverters with a power rating of up to 20 MW.

In designing electric drive control systems, one should employ standardized systems on all drive mechanisms where thyristor inverters are employed, adopt the most advanced systems on extremely high-speed and precision positioning drives, develop rotational speed sensing units, pulse and code sensors (RSM) taking into account the latest developments abroad, develop small computers for local control systems, and increase the degree of operation readiness of delivered control systems so that drive mechanism setup and adjustment requires only setting the required operating mode.

Extensive adoption of enclosed synchronous electric motors beginning with a power output of 50-100 kilowatts is a promising trend in design of non-controlled electric drive mechanisms. Design and manufacture of a new series of such metallurgical motors, 50-250 kilowatts at 380 volts and 300-3000 kilowatts at 10 kilovolts, will make it possible to eliminate intermediate voltage steps in the electric power supply system. It is necessary to develop a series of 20-63 megawatt synchronous motors for high-output blast furnace blowers and oxygen station compressors. Employment of linear motors with a traveling magnetic field and magnetohydrodynamic drive is anticipated. One promising area is development of metallurgical motors employing cryogenic techniques and the phenomenon of superconductivity.

In order to develop new high-productivity rolling mills and to renovate existing ones, it is necessary further to boost motor unit power output from 11.5 to 16 megawatts, and to 10-12 megawatts for nonreversing mills. In order to increase the load capacity and speed of metallurgical cranes, it is necessary to develop a new series of DC and AC crane motors with a rated moment of up to 10 kN·m and with a power output to 600-800 kilowatts. We must increase the unit power and improve the dynamic indices of series D-800 motors. We should set up the manufacture of series 2P motors, all models, from 0.18 to 200 kilowatts, with built-in tachometer generators. For driving low-speed roll tables with rpm control, without employing reduction gearing, we need a series of roll table induction motors with short-circuited rotor, with rated frequencies of 6 and 10 Hz, 0.5-15 kilowatts power, with 1-4 pole pairs and 1:12 control limit. Induction motors with a frequency limit of 70-80 Hz and control range of 1:25 are needed for driving high-speed roll tables designed to operate at a speed of 25-35 mps.

Organization and Management of Electrical Facilities

A high level of organization and management of equipment servicing and repair is required for retooling production on the basis of extensive electrification and adoption of new, complex machine systems. The principal deficiencies of the present system of organization of servicing and maintenance of electrical equipment is the large number of servicing and maintenance personnel and a more rapid electrical repair expenditures growth curve. Centralization and specialization of equipment maintenance and repair service is essential. Toward this end operations maintenance shops will be established, with their own space and equipment and consisting of operations-production brigades specialized in basic operations. The role of the central electrical equipment laboratory is being enhanced, and laboratory facilities will be increased. The electrical maintenance shop and the power lines and substations shop will be specialized, and their facilities will be considerably strengthened. Branch centralized repair services designated for performing laborious jobs and providing spare parts required in large quantities are also being strengthened.

Establishment of a centralized system for servicing electrical facilities will make it possible to implement a uniform technical policy, more uniform work-load personnel, and in particular specialized teams and highly-skilled personnel, more efficiently utilize process tooling and laboratory equipment, improve quality of servicing, reduce down-time of basic equipment for repairs and reduce cost of repairs, adopt critical-path method in planning, with observance of the requisite hierarchy, and set up a unified information-technical and design group. A centralized replacement pool will be established with backup equipment on hand in the shops, by composition and quantity providing replacement of any malfunctioning unit of electrical equipment. It will be possible to change over to scheduled equipment replacement. Establishment of an exchange pool will also make it possible to perform major and medium overhauls in batches, that is, according to the principles of series production.

General Electrical Facilities Problems and Development Trends

Of the most common and substantial problems pertaining to development of electric power engineering at metallurgical enterprises, we should specify problems pertaining to electrical loads (electric power consumption) and circuitry design, establishment of categories, securement of reliability of electric power supply and stability of electrical facilities operation, guarantee of quality of electric power, and problems of evolution of electrical facilities with a quantitative growth and qualitatively increasing complexity of newly-adopted electrical equipment.

Correct determination of loads is the main problem of electric power engineering. In ferrous metallurgy the load on power supply system elements is only 25-40%.

Establishment of an information base at enterprises and at design institutes, and an "Energouchet" system on this information base, will make it possible at the technical-economic substantiation and preliminary design stages correctly to calculate the anticipated electric power loads, utilizing the known methods in a combined manner, and avoiding errors which have cropped up in some older designs.

The design process -- determination of requisite technical-economic indices and optimization of layout -- must be automated, with employment of modern computer hardware, based on forecast development of electrical facilities and stability of electrical indices on a time axis.

Securement of quality of electric power for ferrous metallurgy has become particularly important in connection with the extensive adoption of semiconductor power converters, increase in the unit power output of rolling mill electric drive units, and development of electric steelmaking production. More than 9000 mercury converters representing an aggregate power of approximately 2500 megawatts and more than 41,000 semiconductor power converters totaling approximately 5200 megawatts have been installed at enterprises of this branch. The power of static converters comprises 15% of the installed power of electrical equipment, and the power of furnace transformers -- 13.5% of the output of all power transformers of fourth and larger sizes.

Analysis of electric power quality indices for three-phase three-wire lines for individual enterprises indicated that violations of the requirements of GOST 13109-67 are characteristic chiefly of metallurgical enterprises which have been involved in intensive construction in the last 10-15 years, the percentage share of static converters at which is higher and exceeds 30%. Voltage fluctuations reach 12%, and the coefficient of higher harmonics runs as high as 20% at certain points and in certain modes.

Of the existing methods of compensating for reactive power, noncontrolled banks of capacitors and synchronous compensators are widely employed in ferrous metallurgy. Only experimental-commercial filters have as yet been built for reducing higher harmonics.

Accomplishment of the task of achieving a cardinal improvement in quality of electric power is complicated by an inadequate degree of elaboration of a number of theoretical problems, by lack of series-manufactured monitoring instruments and modern compensating devices, as well as delay in production of directive documents on organizational matters. In recent designs the cost of measures providing high-quality electric power has approached the cost of the power supply system proper.

Problems of establishment of plant electrical facilities are characterized by a rapid quantitative growth and qualitative increase in complexity of electrical equipment. Electric supply systems of large metallurgical enterprises are today no longer inferior to regular power systems in terms of transmitted and distributed power and quantity of installed electrical equipment. Power supplying organizations usually require that metallurgical enterprises build at their own expense power generating plants, communication links, high-voltage step-down and distribution substations, a practice which is faulty. The interests of national and industrial power engineering should be brought into agreement.

Economizing in Electric Power

Much attention has always been focused on questions pertaining to the fuel-energy balance in ferrous metallurgy (this branch consumes approximately 20% of the total fuel consumed in the national economy).

The question of economizing in electric power is extremely important at the present time, and in particular a relative decrease in the size of electric power loads and a relative reduction in the consumption of electric power. The significance of these facts will increase.

Equalization of the load schedules at metallurgical enterprises is of great importance for the nation's economy. For example, average specific capital investment per kilowatt at the Ekibastuz GRES has been determined at 240 rubles. Correspondingly a load decrease at the enterprises of this branch by 10% would make it possible to achieve savings of approximately 300 million rubles. Work is in progress to equalize schedules by changing the operating modes of electric steelmaking furnaces, schedule-shifting the rolling of high-energy-requirement shapes, adjustment of the operation of pumping, compressor, and oxygen stations, etc. This work must be stepped up, however.

This branch has achieved considerable results in producing savings of electric power proper. More than 5100 organizational-technical measures in 1978 secured savings of approximately 3 billion kilowatt hours. Following are the principal areas to economize in electric power consumption: renovation and modernization of process equipment; improvement of manufacturing processes; automation of production processes and mechanization of laborious operations; improvement in manufacture of electric power carriers and their efficient expenditure; renovation, modernization and replacement of obsolete electrical equipment; improved efficiency of electric power supply layout, adoption of remote control, and reduction of line losses; increased equipment loading, decreased down-time and no-load operation; greater efficiency of lighting.

An analysis indicates that the bulk of savings (58%) is achieved with an efficient manufacturing process; electric service provides savings of 27%. Equalization of load schedules is determined chiefly by manufacturing-process measures. Therefore the task of achieving power savings is a combined one, and successful resolution requires greater attention on the part of metallurgical process engineers.

The ever increasing importance of electrification of metallurgical enterprises is an objective process, which began with Lenin's GOELRO plan. History confirms the correctness of a policy of a priority growth rate for electric power engineering. Formulating today's tasks in the campaign for efficiency and quality in our nation's economy, Comrade L. I. Brezhnev noted at the October (1976) CPSU Central Committee Plenum the necessity of increasing the efficiency of such basic branches of the nation's

economy as the extractive industry, power engineering, and metallurgy. Electrical engineers in ferrous metallurgy will make every effort to accomplish the tasks assigned to this branch.
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PLASTIC TREATMENT OF METALS AND ALLOYS

Moscow PLASTICHESKAYA OBRABOTKA METALLOV I SPLAVOV in Russian 1979 signed to press 10 May 79 pp 2, 214-216

[Annotation and table of contents from book edited by Academician N. V. Ageyev, Nauka, 1700 copies, 224 pages]

[Text] The collection presents the results of research done at the laboratory of the Institute of Metallurgy imeni A. A. Baykov, Academy of Sciences USSR, directed by Associate Member of the Academy I. M. Pavlov, dealing with problems of the theory and practice of plastic treatment of different metals and alloys, including multilayered and composite materials. An examination is made of ductility and strength properties and of the influence of peculiarities of the structure of the materials and processes of plastic treatment on the structure and properties of the finished product. The book is intended for research workers and technicians, metallurgists, metal scientists and technologists working in the field of plastic deformation of metals and alloys, and also students of metallurgical and machine-building institutions of higher education.

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UDC 669.018+669.3/6

MAGNESIUM ALLOYS WITH YTTRIUM

Moscow MAGNIYEVYYE SPALVY S ITTRIYEM in Russian 1979 signed to press 18 May 79, back cover, p 162

[Annotation and table of contents from book by M. Ye. Drits, L. L. Rokhlin, Ye. M. Padezhnova, I. I. Gur'yev, N. V. Miklina, T. V. Dobatkina and A. A. Oreshkina, Nauka, 950 copies, 164 pages]

[Text] The book presents the results of research and development of new high-strength and high-temperature alloys based on the magnesium-yttrium system. A detailed examination is made of problems of physicochemical interaction of magnesium with yttrium in binary, ternary and more complex magnesium systems that contain yttrium. The characteristics and structure are given for alloys that are of practical interest. Problems are included that relate to the technology of casting and pressure working these alloys, corrosion properties, and also accident prevention.

The book is intended for workers in scientific research institutes, technicians, engineers and designers working on the development and use of new light alloys. It will also be of interest to the teaching and professional staff, undergraduate and graduate students of metallurgical, machine building and technological institutions of higher education.

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UDC 539.21

THE PHYSICS OF METALLIC FILMS: DIMENSIONAL AND STRUCTURAL EFFECTS

Moscow FIZIKA METALLICHESKIKH PLENOK: RAZMERNYYE I STRUKTURNYYE EFFEKTY in Russian signed to press 22 Jan 79 pp 2, 262-263

[Annotation and table of contents from book by Yuriy Fedorovich Komnik, Atomizdat, 3000 copies, 264 pages]

[Text] The book presents general problems of the physics of thin metallic films: the mechanism of formation of vacuum condensates, the influence of condensation conditions on film structure, change in the temperature boundaries of stable existence of crystalline and amorphous phases with reduction of film thickness, particulars of the electrical and superconductive properties of thin metallic films. Particular attention is given to examination of structural and size effects in thin films. The most timely current problems in the field of investigation of the electronic properties of metal films are discussed.

The book can be recommended to scientific workers and engineers in the field of solid state physics, and those dealing with problems of the physics of thin films, superconductivity, vacuum condensation, and also with the practical utilization of thin films in nuclear and physics research, in microelectronics, optics and measurement technology.

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PHYSICO-CHEMICAL PROPERTIES OF RHENIUM ALLOYS

Moscow FIZIKO-KHIMICHESKIYE SVOYSTVA SPLAVOV RENIYA in Russian 1979 signed to press 29 Mar 79 pp 2, 204-206

[Annotation and table of contents from book edited by Ye. M. Savitskiy, corresponding member of the USSR Academy of Sciences, and M. A. Tylkina, Doctor of Technical Sciences, Nauka, 850 copies, 216 pages]

[Text] This collection on the problem of rhenium includes articles on the investigation of physico-chemical interaction and phase diagrams of rhenium with transition metals, development and investigation of the properties of new alloys (wear-resistant, corrosion-resistant, high-temperature, high-strength, elastic, emissive, with high electrical resistance, etc.). Data are given on the use of rhenium alloys in different areas of modern technology -- electronics, instrument making and so on. Considerable attention is given to the use of rhenium in microelectronics in thin-film high-resistance resistors. A report is given on the properties of high-temperature thermocouples. The collection will be useful to physical metallurgists, chemical physicists, metal physicists, engineering and technical workers in metallurgical and machine building enterprises, and also to instructors and students in metallurgical, chemical and machinebuilding institutions of higher education.

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